FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Environmental Assessment and Restoration, Bureau of Watershed Restoration

SOUTHEAST DISTRICT • ST. LUCIE – LOXAHATCHEE RIVER BASINS

TMDL Report

Fecal Coliform TMDL for Tenmile Creek WBID 3194A

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DEPARTMENT OF ENVIRONMENTAL PROTECTION
FLORIDA

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Websites

Florida Department of Environmental Protection, Bureau of Watershed Restoration

TMDL Program

http://www.dep.state.fl.us/water/tmdl/index.htm

Identification of Impaired Surface Waters Rule

http://www.dep.state.fl.us/legal/Rules/shared/62-303/62-303.pdf

Florida STORET Program

http://www.dep.state.fl.us/water/storet/index.htm

2010 Integrated Report

http://www.dep.state.fl.us/water/docs/2010_Integrated_Report.pdf

Criteria for Surface Water Quality Classifications

http://www.dep.state.fl.us/water/wqssp/classes.htm

Basin Status Report: St. Lucie-Loxahatchee River

http://www.dep.state.fl.us/water/basin411/stlucie/status.htm

Water Quality Assessment Report: St. Lucie-Loxahatchee River

http://www.dep.state.fl.us/water/basin411/stlucie/assessment.htm

U.S. Environmental Protection Agency

Region 4: TMDLs in Florida

http://www.epa.gov/region4/water/tmdl/florida/

National STORET Program

http://www.epa.gov/storet/

Chapter 1: INTRODUCTION

1.1 Purpose of Report

This report presents the Total Maximum Daily Load (TMDL) for fecal coliform bacteria for the Tenmile Creek, located in the St. Lucie and Loxahatchee Basins. The estuary was verified as impaired for fecal coliform, and therefore was included on the Verified List of impaired waters for the St. Lucie and Loxahatchee Basins that was adopted by Secretarial Order on May 19, 2009. The TMDL establishes the allowable fecal coliform loading to Tenmile Creek that would restore the waterbody so that it meets its applicable water quality criterion for fecal coliform.

1.2 Identification of Waterbody

For assessment purposes, the Florida Department of Environmental Protection (Department) has divided the St. Lucie and Loxahatchee Basins into water assessment polygons with a unique **W**ater**B**ody **ID**entification (WBID) number for each watershed or stream reach. Tenmile Creek has been identified as WBID 3194A.

The Tenmile Creek is one of the five waterbody segments identified in the North St. Lucie Planning Unit and 1 of 69 WBIDs located in the St. Lucie – Loxahatchee River Basin, and 1 of 87 waterbody segments in the Southeast Florida Coast basin included on the 1998 303(d) list for Florida. The watershed is located in the central part of St. Lucie County. (**Figure 1.1**).

Tenmile Creek originates in the central St. Lucie County from the confluence of irrigation canals and surface seepage. Tenmile Creek flows in a general easterly direction for approximately 4 miles until it meets with Fivemile Creek to form the North Fork St. Lucie River. (**Figure 1.2**).

The drainage area within the Tenmile Creek is approximately 73.8 square miles (47,232 acres) and is predominantly made up of agriculture land uses. Additional information about the hydrology and geology of this area is available in the Basin Status Report for the St. Lucie – Loxahatchee Basin (Department, 2003).

WBID 3194A is located in the Eastern Florida Flatwoods ecoregion, which occupies parts of central and east Florida. This ecoregion is comprised of low flat land generally containing poorly drained, sandy soils gently sloping towards the east. While the availability of water varies with the local topography and seasonal rainfall, the soil areas may stay wet for much of the year since the flatness of the land reduces water run-off. In low elevations, the land may hold water for several months. At higher elevations, where the water table is deeper, little or no surface water may be visible.

The surficial aquifer is unconfined and at or near the surface in much of the region. Surface water readily moves through, exchanging with the near surface aquifer, and there may be discharge from the surficial aquifer system to the surface based upon regional rain events. In these unconfined areas, the aquifer may be exposed or is covered by a thin layer of sand or by clayey, residual soil (Miller, 1990).

1.3 Background

This report is part of the Department's watershed management approach for restoring and protecting state waters under TMDL Program requirements. The watershed approach looks at waterbodies in a larger geographic context of 52 river basins. This is implemented by organizing the basins into five groups, with an individual basin group evaluated during a given single year, all basins are assessed during a 5-year cycle. The TMDL Program implements the requirements of the 1972 federal Clean Water Act and the 1999 Florida Watershed Restoration Act (FWRA) (Chapter 99-223, Laws of Florida).

A TMDL represents the maximum amount of a given pollutant that a waterbody can assimilate and still meet water quality standards, specifically its applicable water quality criteria and its designated uses. TMDLs are developed for waterbodies that are verified as not meeting their water quality standards, as set by the State of Florida. They provide important water quality restoration goals that will guide restoration activities.

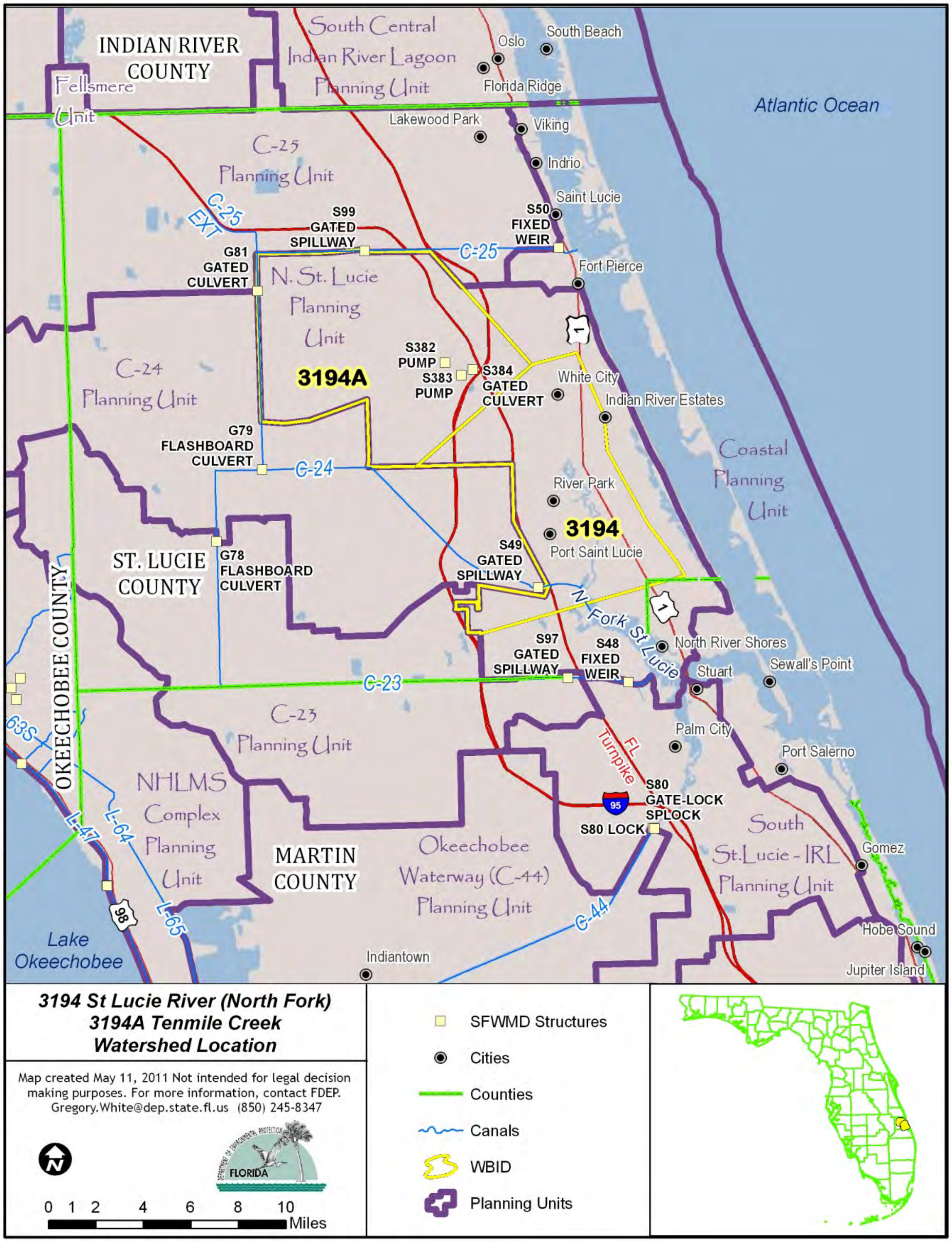

Figure 1.1. Location of the Tenmile Creek Watershed (WBID 3194A) in the St. Lucie-Loxahatchee River Basins and Major Geopolitical and Hydrologic Features in the Area

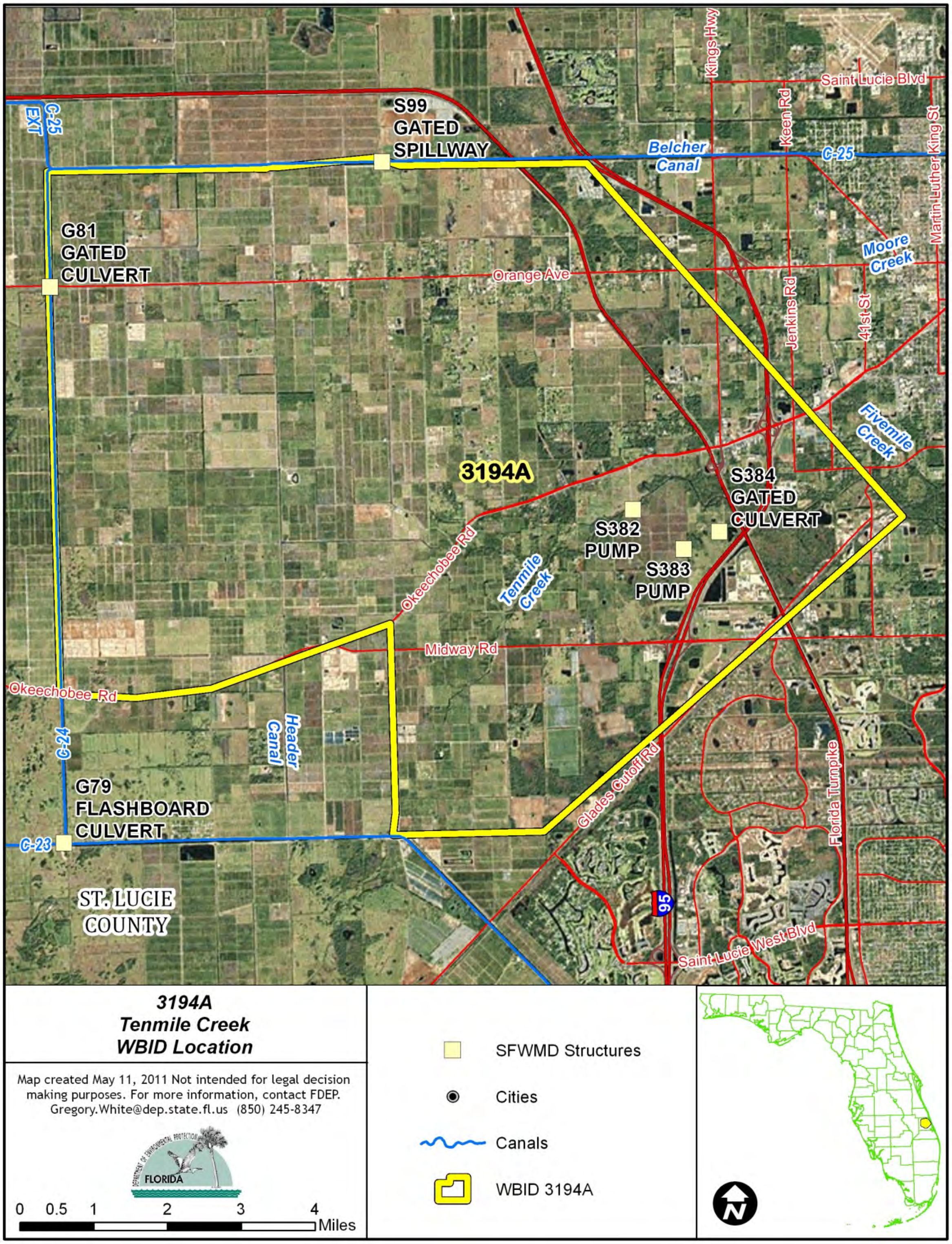

Figure 1.2. Location of the Tenmile Creek Watershed (WBID 3194A) in St. Lucie County and Major Hydrologic Features in the Area

This TMDL report will be followed by the development and implementation of a restoration plan designed to reduce the amount of fecal coliform below levels of impairment for Tenmile Creek. These activities will solicit and include the active participation of the local citizen groups, as well as local and regional political entities such South Florida Water Management District (SFWMD), municipal governments, businesses, and other stakeholders. The Department will work with these organizations and individuals to undertake or continue reductions in the discharge of pollutants and achieve the established TMDLs for impaired waterbodies.

Chapter 2: DESCRIPTION OF WATER QUALITY PROBLEM

2.1 Statutory Requirements and Rulemaking History

Section 303(d) of the federal Clean Water Act requires states to submit to the U.S. Environmental Protection Agency (EPA) lists of surface waters that do not meet applicable state water quality standards (impaired waters) and establish a TMDL for each pollutant causing the impairment of listed waters on a schedule. The Department has developed such lists, commonly referred to as 303(d) lists, since 1992. The list of impaired waters in each basin, referred to as the Verified List, is also required by the Florida Watershed Restoration Act (FWRA, Subsection 403.067[4], Florida Statutes [F.S.]); the state's 303(d) list is amended annually to include basin updates.

Florida identified 87 impaired waterbodies in the Southeast Florida Coast Basin on its 1998 303(d) list. However, the FWRA (Section 403.067, F.S.) stated that all Florida 303(d) lists created before the adoption of the FWRA were for planning purposes only and directed the Department to develop, and adopt by rule, a new science-based methodology to identify impaired waters. After an extended rulemaking process, the Environmental Regulation Commission adopted the new methodology as Rule 62-303, Florida Administrative Code (F.A.C.) (Identification of Impaired Surface Waters Rule, or IWR), in April 2001; the rule was modified in 2006 and 2007.

2.2 Information on Verified Impairment

The Department used the IWR to assess water quality impairments in Tenmile Creek and has verified that this waterbody segment is impaired for fecal coliform bacteria. The verified impairment was based on the observation that for 9 out of 45 fecal coliform samples collected during the Cycle 2 verified period (January 1, 2001, through June 30, 2008), more than 10 percent of the values exceeded the assessment threshold of 400 counts per 100 milliliters (counts/100mL) at 90% confidence level using the binomial distribution (see **Section 3.2** for details).

Table 2.1 summarizes fecal coliform monitoring results for the Cycle 2 verified period for Tenmile Creek used in verifying fecal coliform impairment.

Table 2.1. Summary of Fecal Coliform Monitoring Data for Tenmile Creek Watershed (WBID 3194A) During the Cycle 2 Verified Period (January of 2001 through June of 2008)

This is a three-column table. Column 1 lists the waterbody and WBID number, Column 2 lists the parameter, and Column 3 lists the Cycle 2 results.

Waterbody (WBID)	Parameter	Fecal Coliform
Tenmile Creek Watershed (WBID 3194A)	Total number of samples	45
Tenmile Creek Watershed (WBID 3194A)	IWR-required number of exceedances for the Verified List	8
Tenmile Creek Watershed (WBID 3194A)	Number of observed exceedances	9
Tenmile Creek Watershed (WBID 3194A)	Number of observed nonexceedances	36
Tenmile Creek Watershed (WBID 3194A)	Number of seasons during which samples were collected	4
Tenmile Creek Watershed (WBID 3194A)	Highest observation (counts/100mL)	13,900
Tenmile Creek Watershed (WBID 3194A)	Lowest observation (counts/100mL)	6
Tenmile Creek Watershed (WBID 3194A)	Median observation (counts/100mL)	80
Tenmile Creek Watershed (WBID 3194A)	Mean observation (counts/100mL)	880

Chapter 3. DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND TARGETS

3.1 Classification of the Waterbody and Criterion Applicable to the TMDL

Florida's surface waters are protected for five designated use classifications, as follows:

Class I	**Potable water supplies**
Class II	**Shellfish propagation or harvesting**
Class III	**Recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife**
Class IV	**Agricultural water supplies**
Class V	**Navigation, utility, and industrial use (there are no state waters currently in this class)**

Tenmile Creek is a Class III (predominantly fresh waters) waterbody, with a designated use of Recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife. The criterion applicable to this TMDL is the Class III freshwater criterion for fecal coliform.

3.2 Applicable Water Quality Standards and Numeric Water Quality Target

Numeric criteria for bacterial quality are expressed in terms of fecal coliform bacteria concentration. The water quality criterion for the protection of Class III (fresh) waters, as established by Rule 62-302, F.A.C., states the following:

Fecal Coliform Bacteria:

The most probable number (MPN) or membrane filter (MF) counts per 100 mL of fecal coliform bacteria shall not exceed a monthly average of 200, nor exceed 400 in 10 percent of the samples, nor exceed 800 on any one day.

The criterion states that monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30-day period. There were insufficient data (fewer than 10 samples in a given month) available to evaluate the geometric mean criterion for fecal coliform bacteria. Therefore, the criterion selected for the TMDL was not to exceed 400 counts/100mL in any sampling event for fecal coliform.

Chapter 4: ASSESSMENT OF SOURCES

4.1 Types of Sources

An important part of the TMDL analysis is the identification of pollutant source categories, source subcategories, or individual sources of pollutants in the impaired waterbody and the amount of pollutant loadings contributed by each of these sources. Sources are broadly classified as either “point sources” or “nonpoint sources.” Historically, the term “point sources” has meant discharges to surface waters that typically have a continuous flow via a discernable, confined, and discrete conveyance, such as a pipe. Domestic and industrial wastewater treatment facilities (WWTFs) are examples of traditional point sources. In contrast, the term “nonpoint sources” was used to describe intermittent, rainfall-driven, diffuse sources of pollution associated with everyday human activities, including runoff from urban land uses, agriculture, silviculture, and mining; discharges from failing septic systems; and atmospheric deposition.

However, the 1987 amendments to the Clean Water Act redefined certain nonpoint sources of pollution as point sources subject to regulation under the EPA’s National Pollutant Discharge Elimination System (NPDES) Program. These nonpoint sources included certain urban stormwater discharges, such as those from local government master drainage systems, construction sites over five acres, and a wide variety of industries (see **Appendix A** for background information on the federal and state stormwater programs).

To be consistent with Clean Water Act definitions, the term “point source” will be used to describe traditional point sources (such as domestic and industrial wastewater discharges) ***and*** stormwater systems requiring an NPDES stormwater permit when allocating pollutant load reductions required by a TMDL (see **Section 6.1**). However, the methodologies used to estimate nonpoint source loads do not distinguish between NPDES stormwater discharges and non-NPDES stormwater discharges, and as such, this source assessment section does not make any distinction between the two types of stormwater.

4.2 Potential Sources of Fecal Coliform within the Tenmile Creek WBID Boundary

4.2.1 Point Sources

Wastewater Point Sources

There are no NPDES permitted facilities in the Tenmile Creek watershed which are expected to contribute to the fecal coliform impairment.

Municipal Separate Storm Sewer System Permittees

There is one NPDES Phase IIC municipal separate storm sewer system (MS4) permits in the Tenmile Creek watershed. St. Lucie County (Permit #FLR04E029) has a Phase IIC MS4 permit which covers the entire Tenmile Creek watershed.

4.2.2 Land Uses and Nonpoint Sources

Accurately quantifying the fecal coliform loadings from nonpoint sources requires identifying nonpoint source categories, locating the sources, determining the intensity and frequency with which these sources create high fecal coliform loadings, and specifying the relative contributions from these sources. Depending on the land use distribution in a given watershed, frequently cited nonpoint sources in urban areas include failed septic tanks, leaking sewer lines, and pet feces. If this were a watershed dominated by agricultural land uses, fecal coliform loadings can come from the runoff from areas with animal feeding operations or direct animal access to receiving waters, would also be considered; however, they are not due to no agriculture of note.

In addition to the sources associated with the anthropogenic activities, birds and other wildlife can also contribute fecal coliform to receiving waters. While detailed source information is not always available to quantify accurately the fecal coliform loadings from different sources, land development information can provide some indications on the potential sources of observed fecal coliform impairment. Site review provides evidence of wildlife usage such as rookeries or loafing areas which may be coincident to or upstream from sampling locations.

Land Uses

The spatial distribution and acreage of different land use categories were identified using the SFWMD's 2004-05 land use coverage contained in the Department's geographic information system (GIS) library. Land use categories within the Tenmile Creek WBID boundary were aggregated using the Florida Land Use Code and Classification System (FLUCCS) expanded Level 1 codes (including low, medium, and high density residential) and tabulated in **Table 4.1**. **Figure 4.1** shows the spatial distribution of the principal land uses within the WBID boundary.

As shown in **Table 4.1**, the total area within the Tenmile Creek WBID boundary is approximately 47,232 acres. The dominant land use categories are agriculture (~34,549 ac., 73% coverage), low density residential (2,886 acres, 6% coverage), and remnant upland forest (~2,628 ac., 5% coverage). Roads and infrastructure have significant cover (~3%) indicating impacts to historic surface flows.

Table 4.1. Classification of Land Use Categories within the Tenmile Creek WBID 3194A Boundary

This is a four-column table. Column 1 lists the Level 1 land use code, Column 2 lists the land use, Column 3 lists the acreage, and Column 4 lists the percent acreage.

- = Empty cell/no data

Level 1 Code	3194A Land Use	Acres	% Acreage
1000	Urban and Built up	2,239	4.7
-	Low Density Residential	2,886	6.1
-	Medium Density Residential	143	0.3
-	High Density Residential	124	0.3
2000	Agricultural	34,549	73.1
3000	Rangeland	1,055	2.2
4000	Upland Forest	2,628	5.6
5000	Water	721	1.5
6000	Wetlands	1,412	3.0
7000	Barren Land	84	0.2
8000	Transportation, Communication, and Utilities	1,392	2.9
	TOTAL	**47,232**	**100.0%**

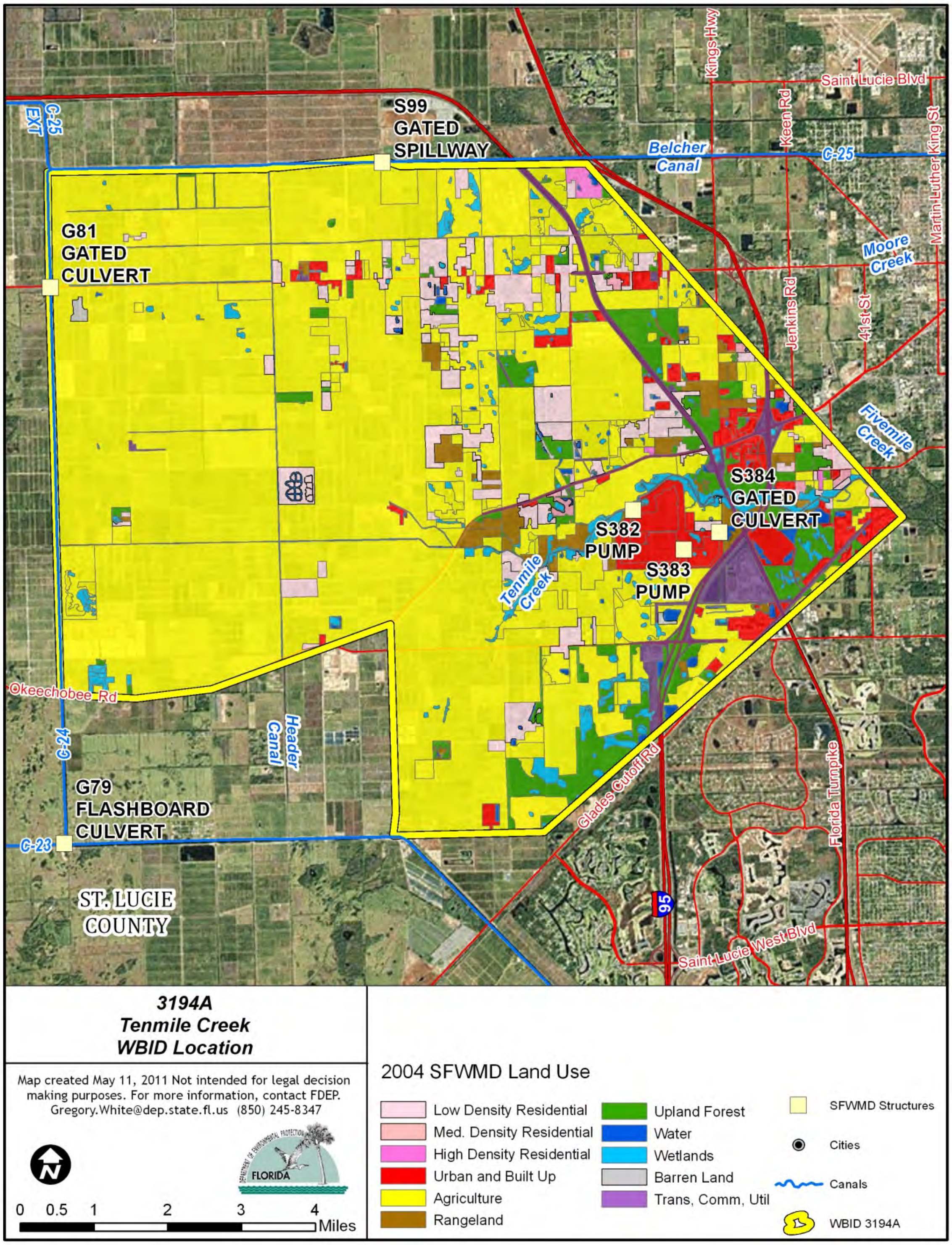

Figure 4.1. Principal Land Uses within the Tenmile Creek (WBID 3194A) Boundary

Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Determination of Loading Capacity

When continuous flow measurements in a watershed are available, a bacteria TMDL can be developed using the load duration curve method, which was developed by the Kansas Department of Health and Environment and provides the allowable daily bacteria load. However, necessary flow data were not available for Tenmile Creek; therefore, the fecal coliform TMDL was developed using the “percent reduction” approach. Using this method, the percent reduction needed to meet the applicable criterion is calculated based on the 90th percentile of all measured concentrations collected during the Cycle 2 verified period (January 1, 2001–June 30, 2008). Because bacteriological counts in water are not normally distributed a nonparametric method is more appropriate for the analysis of fecal coliform data (Hunter, 2002). The Hazen method, which uses a nonparametric formula, was used to determine the 90th percentile. The EPA Region 4 uses this method in developing fecal coliform TMDLs. The percent reduction of fecal coliform needed to meet the applicable criterion was calculated as described in **Section 5.1.3**.

5.1.1 Data Used in the Determination of the TMDL

Data used to develop this TMDL were from IWR database for Stations: 21FLWPB 28010007 (n=13), 21FLWPB 28010041 (n=13), 21FLWPB 28010045 (n=14), and 21FLWPB 28010881 (n=5). **Figure 5.1** shows the locations of the water quality stations where fecal coliform data were collected for Tenmile Creek.

At the time of the assessment, the Department verified the water quality impairment in Tenmile Creek on the observation that 9 out of 45 fecal coliform samples collected during the Cycle 2 verified period (January of 2001, through June of 2008) exceeded the assessment threshold of 400 counts/100mL.

The Cycle 2 verified period includes data collected from January of 2001 through June of 2008. During this period, a total of 45 fecal coliform samples were collected from the sampling stations in WBID 3194A.

The fecal coliform data for Tenmile Creek collected were spread out over the Cycle 2 verified period, so this analysis focuses on fecal coliform data collected for the duration of the Cycle 2 verified period.

Concentrations for all samples collected during the Cycle 2 verified period ranged from 6 to 13,900 counts/100mL and averaged 880 counts/100mL during the period of observation. **Table 5.1** summarizes the descriptive statistics for the fecal coliform results. **Figure 5.2** shows the fecal coliform concentration trends observed in Tenmile Creek.

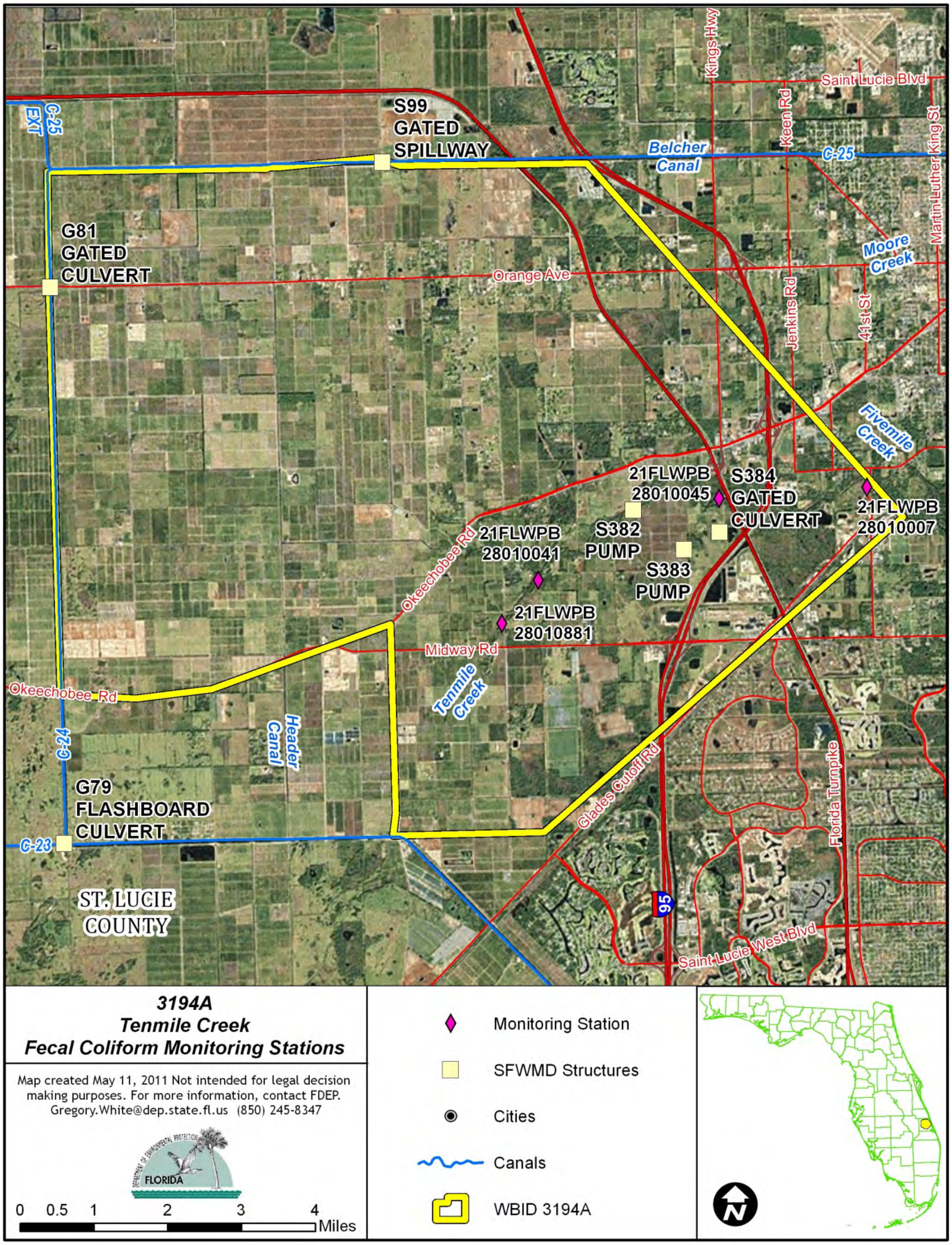

Figure 5.1. Location of Water Quality Stations with Fecal Coliform Data in Tenmile Creek (WBID 3194A)

Table 5.1. Descriptive Statistics of Fecal Coliform Data for Tenmile Creek (WBID 3194A) for Cycle 2 Verified Period

This is a two-column table. Column 1 lists the descriptive statistic, and Column 2 lists the result.

Descriptive Statistic	Result
Number of samples	45
Mean observation (counts/100mL)	880
Standard deviation	2,641
Median observation (counts/100mL)	80
Highest observation (counts/100mL)	13,900
Lowest observation (counts/100mL)	6
25% quartile	25
75% quartile	270

Temporal Patterns

Fecal coliform data for the Cycle 2 verified period were analyzed for annual and seasonal trends. Fecal coliform exceedances occurred across the range of rainfall events and throughout all four calendar quarters.

Seasonally, a peak in fecal coliform concentrations and exceedance rates is expected during the third quarter (summer, July–September), when conditions are rainy and warm, and lower concentrations and exceedance rates are expected in the first and fourth quarters (winter, January–March; and fall, October–December), when conditions are drier and colder. In Tenmile Creek, the highest percent exceedances were recorded in September (50%); however, the maximum count was in November (13,900 counts/100mL),with other high counts occurring during the wet summer months. **Tables 5.2a** and **5.2b** summarize the monthly and seasonal fecal coliform averages and percent exceedances, respectively, for data collected for the Cycle 2 verified period for this waterbody.

Table 5.2a. Summary Statistics of Fecal Coliform Data for All Stations in Tenmile Creek (WBID 3194A) by Month during the Cycle 2 Verified Period

This is an eight-column table. Column 1 lists the month, Column 2 lists the number of samples, Column 3 lists the minimum coliform count/100mL, Column 4 lists the maximum count, Column 5 lists the median count, Column 6 lists the mean count, Column 7 lists the number of exceedances, and Column 8 lists the percent exceedances.

- = Empty cell/no data
[1] Coliform counts are #/100mL.
[2] Exceedances represent values above 400 counts/100mL

Month	Number of Samples	Minimum[1]	Maximum[1]	Median[1]	Mean[1]	Number of Exceedances[2]	% Exceedances
January	-	-	-	-	-	-	-
February	4	24	110	91	79	0	0.0
March	3	31	546	168	248	1	33.3
April	7	6	230	50	71	0	0.0
May	4	40	117	83	81	0	0.0
June	7	12	2,100	82	403	2	28.6
July	-	-	-	-	-	-	-
August	4	6	29	16	17	0	0.0
September	6	270	2,500	385	717	3	50.0
October	3	21	54	35	38	0	0.0
November	7	8	13,900	26	4,346	3	42.9
December	-	-	-	-	-	-	-

Table 5.2b. Summary Statistics of Fecal Coliform Data for All Stations in Tenmile Creek (WBID 3194A) by Season during the Cycle 2 Verified Period

This is an eight-column table. Column 1 lists the season, Column 2 lists the number of samples, Column 3 lists the minimum coliform count/100mL, Column 4 lists the maximum count, Column 5 lists the median count, Column 6 lists the mean count, Column 7 lists the number of exceedances, and Column 8 lists the percent exceedances.

- = Empty cell/no data
[1] Coliform counts are #/100mL.
[2] Exceedances represent values above 400 counts/100mL

Season	Number of Samples	Minimum[1]	Maximum[1]	Median[1]	Mean[1]	Number of Exceedances[2]	% Exceedances
Quarter 1	7	24	546	100	152	1	14.3
Quarter 2	18	6	2,100	68	202	2	11.1
Quarter 3	10	6	2,500	275	437	3	30.0
Quarter 4	10	8	13,900	31	3,053	3	30.0

Using rainfall data collected at the Ft. Pierce CLIMOD station in St. Lucie County (available: http://climod.meas.ncsu.edu/), it was possible to compare monthly rainfall over the years 2003-2008 with monthly fecal coliform exceedance rates for the same period, as well as average quarterly rainfall with average quarterly fecal coliform exceedance rates at all stations (**Figures 5.2** and **5.3**). Peak fecal coliform concentrations commonly coincide with, or follow, periods of increased rainfall; this trend was not observed in Tenmile Creek. These fecal coliform concentrations correlated with 3-day precipitation (extreme and medium precipitation events).

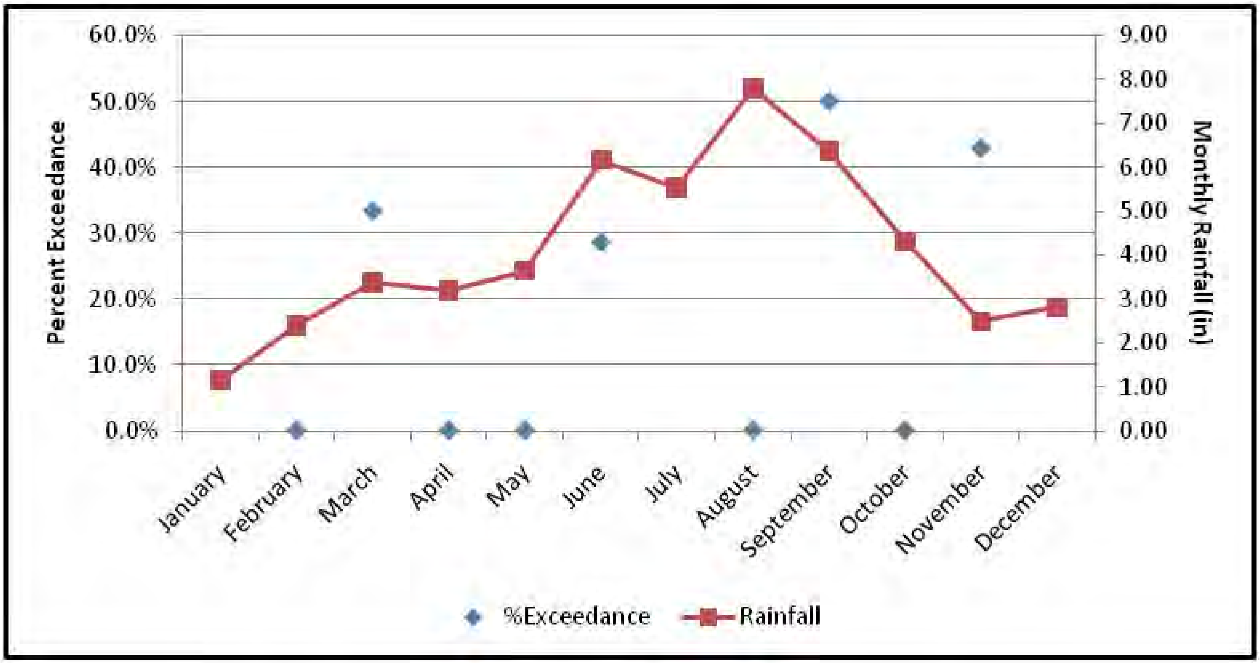

Figure 5.2. Fecal Coliform Exceedances and Rainfall at All Stations in Tenmile Creek (WBID 3194A) by Month during the Cycle 2 Verified Period

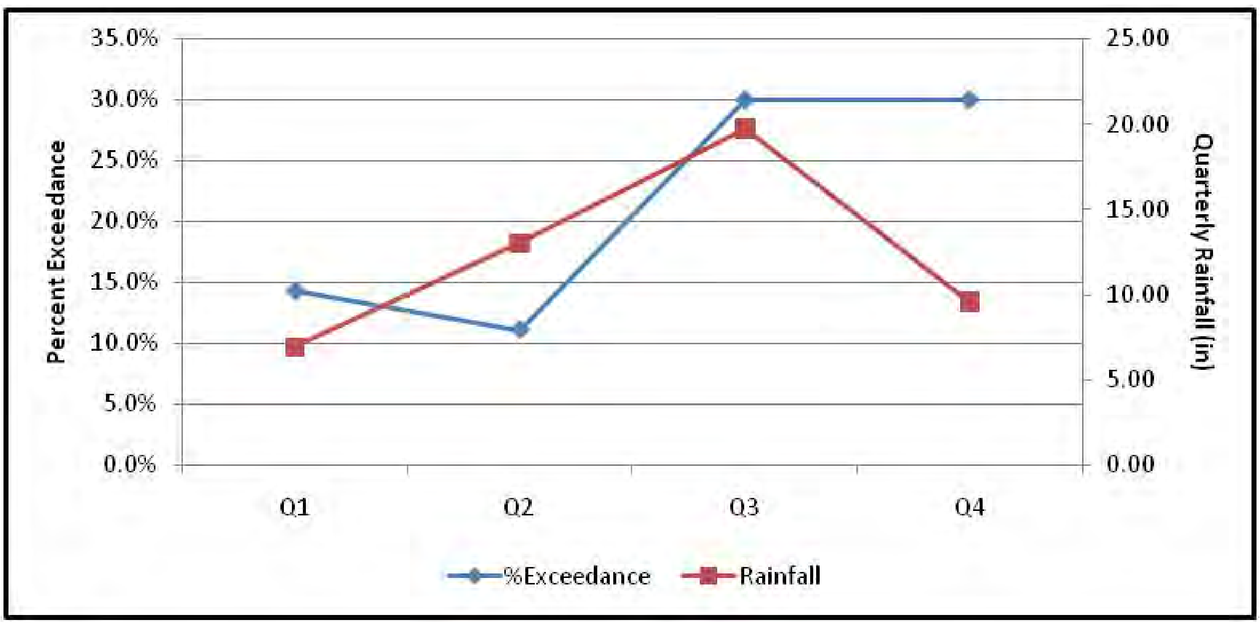

Figure 5.3. Fecal Coliform Exceedances and Rainfall at All Stations in Tenmile Creek (WBID 3194A) by Season during the Cycle 2 Verified Period

Spatial Patterns

Fecal coliform data from Cycle 2 verified period from the stations were analyzed to detect spatial trends in the data (see **Table 5.3**). Fecal coliform concentrations exceeding the state criterion (400 counts/100mL) were observed in 3 of the 4 stations. The highest concentrations were recorded at Station 21FLWPB 28010041 (38% exceedance). This station is located downstream of Station 21FLWPB 28010881 which had a 0.0% exceedance. The two next downstream stations, 21FLWPB 28010045 and 21FLWPB 28010007 had percent exceedances of 14% and 15%, respectively. (**Table 5.3**).

Table 5.3. Station Summary Statistics of Fecal Coliform Data for Tenmile Creek (WBID 3194A) during the Cycle 2 Verified Period

This is a nine-column table. Column 1 lists the station, Column 2 lists the period of observation, Column 3 lists the number of samples, Column 4 lists the minimum count/100mL, Column 5 lists the maximum count, Column 6 lists the median count, Column 7 lists the mean count, Column 8 lists the number of exceedances, and Column 9 lists the percent exceedances.

[1] Coliform counts are #/100mL.
[2] Exceedances represent values above 400 counts/100mL

Station ID	Period of Observation	Number of Samples	Minimum[1]	Maximum[1]	Median[1]	Mean[1]	Number of Exceedance	Percent Exceedance
21FLWPB 28010007	2006-2007	13	22	13,900	110	1,339	2	15
21FLWPB 28010041	2006-2007	13	9	7,455	100	904	5	38
21FLWPB 28010045	2005-2007	14	6	9,000	53	728	2	14
21FLWPB 28010881	2007	5	8	110	29	50	0	0

5.1.2 Critical Condition

The critical condition for coliform loadings in a given watershed depends on many factors, including the presence of point sources and the land use pattern in the watershed. Typically, the critical condition for nonpoint sources is an extended dry period followed by a rainfall runoff event. During the wet weather period, rainfall washes off coliform bacteria that have built up on the land surface under dry conditions, resulting in the wet weather exceedances. However, significant nonpoint source contributions can also appear under dry conditions without any major surface runoff event. This usually happens when nonpoint sources contaminate the surficial aquifer, and fecal coliform bacteria are brought into the receiving waters through baseflow. In addition, the fecal coliform contribution of wildlife with direct access to the receiving water can be more noticeable during dry weather, by contributing to exceedances. The critical condition for point source loading typically occurs during periods of low stream flow, when dilution is minimized.

As no current flow data were available, hydrologic conditions were analyzed using rainfall. A loading curve – a type of chart that would normally be applied to flow events was created using precipitation data from the Ft. Pierce CLIMOD station instead. The chart was divided in the same manner as if flow were being analyzed, where extreme precipitation events represent the lower percentiles (0–5th percentile), followed by large precipitation events (5th–10th percentile), medium precipitation events (10th–40th percentile), small precipitation events (40th–60th percentile), and no recordable precipitation events (60th–100th percentile). Event precipitation ranges were derived based on these percentiles. Extreme events were determined as those with rainfall greater than 2.20 inches; large events, 1.51 to 2.20 inches; medium events, 0.16 to 1.51 inches; small events, 0.01 to 0.15 inches; and non-measurable events, less than 0.01 inch. Three-day (the day of and 2 days prior to sampling) precipitation accumulations were used in the analysis (**Table 5.4** and **Figure 5.5**).

Historical data show that fecal coliform exceedances occurred over extreme, medium, and not measurable precipitation events. Given that no samples were collected during large precipitation events, it can only be assumed, and not generalized, that fecal coliform exceedances occur over all hydrologic conditions.

The highest percentage of exceedances (67% exceedance) occurred after extreme precipitation events, but this period also had the fewest samples (n=3). High exceedance rate was also observed in samples collected after medium precipitation events (38% exceedance). The lowest percentage of exceedances occurred after periods of small or no measurable precipitation (0% and 10% percent exceedance). The fact that the highest exceedance rates occurred after extreme and medium precipitation events, rather than after periods of little or no rainfall, indicates that nonpoint sources are probably a major contributing factor. **Table 5.4** and **Figure 5.5** show fecal coliform data by hydrologic condition.

As fecal coliform exceedances occurred following sampled categories of all types of precipitation events—extreme, medium, small, and not measurable—the target fecal coliform reduction calculated in the following section and shown in **Table 5.5** is applicable under all rainfall conditions in Tenmile Creek.

Table 5.4. Summary of Historical Fecal Coliform Data by Hydrologic Condition for Tenmile Creek (WBID 3194A)

This is a seven-column table. Column 1 lists the type of precipitation event, Column 2 lists the event range (in inches), Column 3 lists the total number of samples, Column 4 lists the number of exceedances, Column 5 lists the percent exceedance, Column 6 lists the number of nonexceedances, and Column 7 lists the percent nonexceedances.

Precipitation Event	Event Range (inches)	Total Samples	Number of Exceedances	Percent Exceedances	Number of Nonexceedances	Percent Nonexceedances
Extreme	>2.2"	3	2	67	1	33
Large	1.51" - 2.20"	0	0	N/A	0	N/A
Medium	0.16" - 1.51"	13	5	38	8	62
Small	0.01" - 0.15"	8	0	0	8	100
None/Not Measurable	<0.01"	21	2	10	19	90

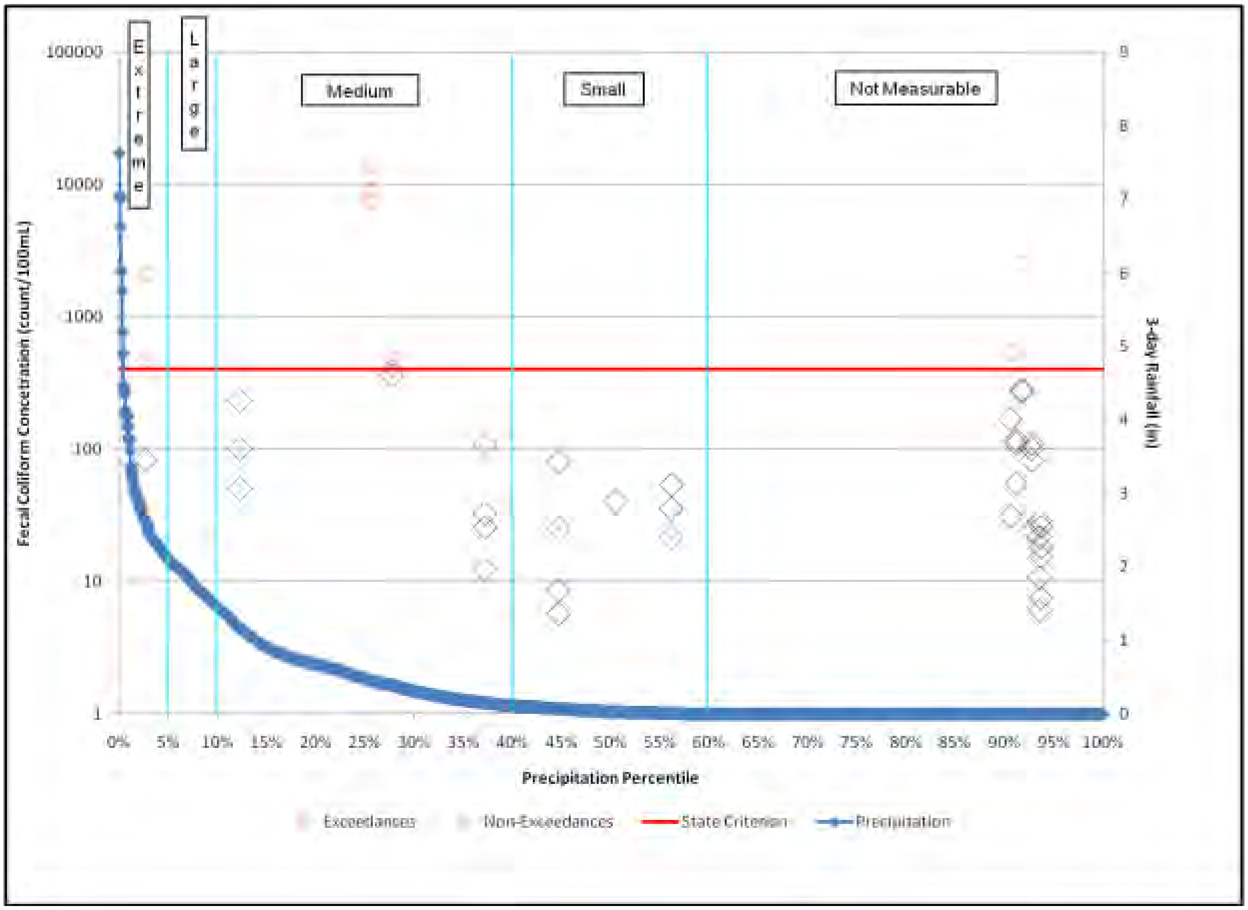

Figure 5.4. Historical Fecal Coliform Data by Hydrologic Condition for Tenmile Creek (WBID 3194A)

Table 5.5. Calculation of Fecal Coliform Reductions for the Tenmile Creek (WBID 3194A) TMDL Based on the Hazen Method

This is a five-column table. Column 1 lists the station, Column 2 lists the sampling date, Column 3 lists the fecal coliform exceedance concentration (MPN/100mL), Column 4 lists the rank, and Column 5 lists the percentile by the Hazen method.

- = Empty cell/no data

Station	Date	Fecal Coliform Concentration (MPN/100 mL)	Rank	Percentile by Hazen Method
21FLWPB 28010045	4/23/2007	5.67	1	1.11%
21FLWPB 28010045	8/16/2007	6	2	3.33%
21FLWPB 28010881	11/6/2007	7.5	3	5.56%
21FLWPB 28010041	4/23/2007	8.5	4	7.78%
21FLWPB 28010041	8/16/2007	10.67	5	10.00%
21FLWPB 28010041	6/14/2007	12.33	6	12.22%
21FLWPB 28010045	11/6/2007	15.33	7	14.44%
21FLWPB 28010041	11/6/2007	18	8	16.67%
21FLWPB 28010041	10/15/2007	21.33	9	18.89%
21FLWPB 28010007	8/16/2007	21.5	10	21.11%
21FLWPB 28010041	2/26/2007	24	11	23.33%
21FLWPB 28010007	4/23/2007	25	12	25.56%
21FLWPB 28010881	6/14/2007	25.5	13	27.78%
21FLWPB 28010007	11/6/2007	26	14	30.00%
21FLWPB 28010881	8/16/2007	28.5	15	32.22%
21FLWPB 28010045	3/14/2006	31	16	34.44%
21FLWPB 28010007	6/14/2007	32.5	17	36.67%
21FLWPB 28010045	10/15/2007	35.33	18	38.89%
21FLWPB 28010045	5/17/2005	40	19	41.11%
21FLWPB 28010045	4/12/2006	50	20	43.33%
21FLWPB 28010007	10/15/2007	53.5	21	45.56%
21FLWPB 28010045	5/22/2006	55	22	47.78%
21FLWPB 28010881	4/23/2007	80	23	50.00%
21FLWPB 28010045	6/27/2006	82	24	52.22%
21FLWPB 28010045	2/26/2007	82	25	54.44%
21FLWPB 28010041	4/12/2006	100	26	56.67%
21FLWPB 28010007	2/26/2007	100	27	58.89%
21FLWPB 28010045	6/14/2007	107.33	28	61.11%
21FLWPB 28010007	5/22/2006	110	29	63.33%
21FLWPB 28010881	2/26/2007	110	30	65.56%
21FLWPB 28010041	5/22/2006	117	31	67.78%
21FLWPB 28010007	3/14/2006	168	32	70.00%
21FLWPB 28010007	4/12/2006	230	33	72.22%

Station	Date	Fecal Coliform Concentration (MPN/100 mL)	Rank	Percentile by Hazen Method
21FLWPB 28010045	9/27/2006	270	34	74.44%
21FLWPB 28010007	9/27/2006	280	35	76.67%
21FLWPB 28010007	9/5/2006	360	36	78.89%
21FLWPB 28010045	9/5/2006	410	37	81.11%
21FLWPB 28010041	6/27/2006	460	38	83.33%
21FLWPB 28010041	9/5/2006	480	39	85.56%
21FLWPB 28010041	3/14/2006	546	40	87.78%
21FLWPB 28010007	6/27/2006	2,100	41	90.00%
21FLWPB 28010041	9/27/2006	2,500	42	92.22%
21FLWPB 28010041	11/1/2006	7,455	43	94.44%
21FLWPB 28010045	11/1/2006	9,000	44	96.67%
21FLWPB 28010007	11/1/2006	13,900	45	98.89%
			Existing condition concentration–90th percentile (counts/100mL)	2,100
			Allowable concentration (counts/100mL)	400
			Final % reduction{(2,100-400)/2,100}	81%

5.1.3 TMDL Development Process

Due to the lack of supporting information, mainly flow data, a simple reduction calculation was performed to determine the reduction in fecal coliform concentration necessary to achieve the concentration target (400 counts/100mL). The percent reduction needed to reduce pollutant load was calculated by comparing the existing concentrations and target concentration using **Formula 1**:

$$\text{Needed \% Reduction} = \frac{\text{Existing } 90^{th} \text{ Percentile Concentration} - \text{Allowable Concentration}}{\text{Existing } \mathbf{90^{th}} \text{ Percentile Concentration}} \times 100$$

Formula 1

Using the Hazen method for estimating percentiles, as described in Hunter (2002), the existing condition concentration was defined as the 90th percentile of all the fecal coliform data collected during the Cycle 2 verified period (January 1, 2001–June 30, 2008). The 90th percentile is also called the 10 percent exceedance event. This will result in a target condition that is consistent with the state bacteriological water quality assessment threshold for Class III waters.

In applying this method, all of the available data are ranked (ordered) from the lowest to the highest (**Table 5.5**), and **Formula 2** is used to determine the percentile value of each data point.

$$\text{Percentile} = \frac{\text{Rank} - 0.5}{\text{Total Number of Samples Collected}} \times 100$$

Formula 2

If none of the ranked values is shown to be the 90th percentile value, then the 90th percentile number (used to represent the existing condition concentration) is calculated by interpolating between the two data points adjacent (above and below) to the desired 90th percentile rank using **Formula 3,** as described below.

$$90^{\mathrm{th}}\ \text{Percentile Concentration} = \mathrm{C}_{\mathrm{lower}} + (\mathrm{P}_{90\mathrm{th}} * \mathrm{R})$$

Formula 3

Where:

C_{lower} is the fecal coliform concentration corresponding to the percentile lower than the 90th percentile, in this case, 460 counts/100mL.

P_{90th} is the percentile difference between the 90th percentile and the percentile number immediately lower than the 90th percentile (for example, 88%), which is 90% – 88% = 2.00%

R is a ratio defined as R= (fecal coliform concentration$_{upper}$ – fecal coliform concentration $_{lower}$)/(percentile$_{upper}$ – percentile$_{lower}$)

In this case, the 90th percentile is not between 2 values, so there is no need to interpolate the 90th percentile.

Using **Formula 1**, the percent reduction for the period of observation (January 1, 2001–June 30, 2008) was calculated as 81 percent for Tenmile Creek (i.e., % reduction needed = [(2,100–400)/2,100]*100 = 81%).

Chapter 6: DETERMINATION OF THE TMDL

6.1 Expression and Allocation of the TMDL

The objective of a TMDL is to provide a basis for allocating acceptable loads among all of the known pollutant sources in a watershed so that appropriate control measures can be implemented and water quality standards achieved. A TMDL is expressed as the sum of all point source loads (wasteload allocations, or WLAs), nonpoint source loads (load allocations, or LAs), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$\textbf{TMDL} = \sum \textbf{WLAs} + \sum \textbf{LAs} + \textbf{MOS}$$

As discussed earlier, the WLA is broken out into separate subcategories for wastewater discharges and stormwater discharges regulated under the NPDES Program:

$$\textbf{TMDL} \cong \sum \textbf{WLAs}_{\textbf{wastewater}} + \sum \textbf{WLAs}_{\textbf{NPDES Stormwater}} + \sum \textbf{LAs} + \textbf{MOS}$$

It should be noted that the various components of the revised TMDL equation may not sum up to the value of the TMDL because (a) the WLA for NPDES stormwater is typically based on the percent reduction needed for nonpoint sources and is also accounted for within the LA, and (b) TMDL components can be expressed in different terms (for example, the WLA for stormwater is typically expressed as a percent reduction, and the WLA for wastewater is typically expressed as mass per day).

WLAs for stormwater discharges are typically expressed as “percent reduction” because it is very difficult to quantify the loads from MS4s (given the numerous discharge points) and to distinguish loads from MS4s from other nonpoint sources (given the nature of stormwater transport). The permitting of stormwater discharges also differs from the permitting of most wastewater point sources. Because stormwater discharges cannot be centrally collected, monitored, and treated, they are not subject to the same types of effluent limitations as wastewater facilities, and instead are required to meet a performance standard of providing treatment to the “maximum extent practical” through the implementation of best management practices (BMPs).

This approach is consistent with federal regulations (40 CFR § 130.2[I]), which state that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or other appropriate measure. The TMDL for Tenmile Creek is expressed in terms of counts/day and percent reduction, and represents the maximum daily fecal coliform load the stream can assimilate without exceeding the fecal coliform criterion (**Table 6.1**).

Table 6.1. TMDL Components for Fecal Coliform in Tenmile Creek (WBID 3194A)

This is a six-column table. Column 1 lists the parameter, Column 2 lists the TMDL (counts/100mL), Column 3 lists the WLA for wastewater (counts/100mL), Column 4 lists the WLA for NPDES stormwater (percent reduction), Column 5 lists the LA (percent reduction), and Column 6 lists the MOS.

N/A = Not applicable

Parameter	TMDL (counts/100mL)	WLA for Wastewater (counts/100mL)	WLA for NPDES Stormwater (% reduction)	LA (% reduction)	MOS
Fecal coliform	400	N/A	81%	81%	Implicit

6.2 Load Allocation

Based on a percent reduction approach, the LA is an 81 percent reduction in fecal coliform from nonpoint sources. It should be noted that the LA includes loading from stormwater discharges regulated by the Department and the water management districts that are not part of the NPDES Stormwater Program (see **Appendix A**).

6.3 Wasteload Allocation

6.3.1 NPDES Wastewater Discharges

There are no NPDES permitted sites in the Tenmile Creek watershed.

It should be noted that any future NPDES permittee is only responsible for reducing the anthropogenic loads associated with stormwater outfalls that it owns or otherwise has responsible control over, and it is not responsible for reducing other nonpoint source loads in its jurisdiction.

Municipal Separate Storm Sewer System Permittees

There is one NPDES Phase IIC municipal separate storm sewer system (MS4) permits in the Tenmile Creek watershed. St. Lucie County (Permit #FLR04E029) has a Phase IIC MS4 permit which covers the entire Tenmile Creek watershed.

It should be noted that any future MS4 permittee is only responsible for reducing the anthropogenic loads associated with stormwater outfalls that it owns or otherwise has responsible control over, and it is not responsible for reducing other nonpoint source loads in its jurisdiction.

6.4 Margin of Safety

Consistent with the recommendations of the Allocation Technical Advisory Committee (Department, 2001), an implicit MOS was used in the development of this TMDL by not subtracting contributions from natural sources and sediments when the percent reduction was calculated. This makes the estimation of human contribution more stringent and therefore adds to the MOS.

Chapter 7: TMDL IMPLEMENTATION

7.1 Basin Management Action Plan

Following the adoption of this TMDL by rule, the Department will determine the best course of action regarding its implementation. Depending on the pollutant(s) causing the waterbody impairment and the significance of the waterbody, the Department will select the best course of action leading to the development of a plan to restore the waterbody. Often this will be accomplished cooperatively with stakeholders by creating a Basin Management Action Plan, referred to as the BMAP. BMAPs are the primary mechanism through which TMDLs are implemented in Florida (see Subsection 403.067[7], F.S.). A single BMAP may provide the conceptual plan for the restoration of one or many impaired waterbodies.

If the Department determines that a BMAP is needed to support the implementation of this TMDL, a BMAP will be developed through a transparent, stakeholder-driven process intended to result in a plan that is cost-effective, technically feasible, and meets the restoration needs of the applicable waterbodies. Once adopted by order of the Department Secretary, BMAPs are enforceable through wastewater and municipal stormwater permits for point sources and through BMP implementation for nonpoint sources. Among other components, BMAPs typically include the following:

- *Water quality goals (based directly on the TMDL);*
- *Refined source identification;*
- *Load reduction requirements for stakeholders (quantitative detailed allocations, if technically feasible);*
- *A description of the load reduction activities to be undertaken, including structural projects, nonstructural BMPs, and public education and outreach;*
- *A description of further research, data collection, or source identification needed in order to achieve the TMDL;*
- *Timetables for implementation;*
- *Implementation funding mechanisms;*
- *An evaluation of future increases in pollutant loading due to population growth;*
- *Implementation milestones, project tracking, water quality monitoring, and adaptive management procedures; and*
- *Stakeholder statements of commitment (typically a local government resolution).*

BMAPs are updated through annual meetings and may be officially revised every five years. Completed BMAPs in the state have improved communication and cooperation among local stakeholders and state agencies; improved internal communication within local governments; applied high-quality science and local information in managing water resources; clarified the obligations of wastewater point source, MS4, and non-MS4 stakeholders in TMDL implementation; enhanced transparency in the Department's decision making; and built strong relationships between the Department and local stakeholders that have benefited other program areas.

7.2 Other TMDL Implementation Tools

In some basins, and for some parameters, particularly those with fecal coliform impairments, the development of a BMAP using the process described above will not be the most efficient way to restore a waterbody, such that it meets its designated uses. This is because fecal coliform impairments result from the cumulative effects of a multitude of potential sources, both natural and anthropogenic. Addressing these problems requires good old-fashioned detective work that is best done by those in the area.

Many assessment tools are available to assist local governments and interested stakeholders in this detective work. The tools range from the simple (such as Walk the WBIDs and GIS mapping) to the complex (such as bacteria source tracking). Department staff will provide technical assistance, guidance, and oversight of local efforts to identify and minimize fecal coliform sources of pollution. Based on work in the Lower St Johns River Tributaries and Hillsborough Basins, the Department and local stakeholders have developed a logical process and tools to serve as a foundation for this detective work.

In the near future, the Department will be releasing these tools to assist local stakeholders with the development of local implementation plans to address fecal coliform impairments. In such cases, the Department will rely on these local initiatives as a more cost-effective and simplified approach to identify the actions needed to put in place a road map for restoration activities, while still meeting the requirements of Subsection 403.067(7), F.S.

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Appendices

Appendix A: Background Information on Federal and State Stormwater Programs

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as authorized in Chapter 403, F.S., was established as a technology-based program that relies on the implementation of BMPs that are designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Rule 62-40, F.A.C. In 1994, the Department's stormwater treatment requirements were integrated with the stormwater flood control requirements of the water management districts, along with wetland protection requirements, into the Environmental Resource Permit regulations.

Rule 62-40, F.A.C., also requires the state's water management districts to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a Surface Water Improvement and Management (SWIM) plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL. To date, they have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka.

In 1987, the U.S. Congress established Section 402(p) as part of the federal Clean Water Act Reauthorization. This section of the law amended the scope of the federal NPDES permitting program to designate certain stormwater discharges as "point sources" of pollution. The EPA promulgated regulations and began implementing the Phase I NPDES Stormwater Program in 1990. These stormwater discharges include certain discharges that are associated with industrial activities designated by specific standard industrial classification (SIC) codes, construction sites disturbing 5 or more acres of land, and the master drainage systems of local governments with a population above 100,000, which are better known as MS4s. However, because the master drainage systems of most local governments in Florida are interconnected, the EPA implemented Phase I of the MS4 permitting program on a countywide basis, which brought in all cities (incorporated areas), Chapter 298 urban water control districts, and the Florida Department of Transportation throughout the 15 counties meeting the population criteria. The Department received authorization to implement the NPDES Stormwater Program in 2000.

An important difference between the federal NPDES and the state's stormwater/environmental resource permitting programs is that the NPDES Program covers both new and existing discharges, while the state's program focus on new discharges only. Additionally, Phase II of the NPDES Program, implemented in 2003, expands the need for these permits to construction sites between 1 and 5 acres, and to local governments with as few as 1,000 people. While these urban stormwater discharges are now technically referred to as "point sources" for the purpose of regulation, they are still diffuse sources of pollution that cannot be easily collected and treated by a central treatment facility, as are other point sources of pollution such as domestic and industrial wastewater discharges. It should be noted that all MS4 permits issued in Florida include a reopener clause that allows permit revisions to implement TMDLs when the implementation plan is formally adopted.

Appendix B: Estimates of Fecal Coliform Loadings from Potential Sources

The Department provides these estimates for informational purposes only and did not use them to calculate the TMDL. They are intended to give the public a general idea of the relative importance of each source in the waterbody. The estimates were based on the best information available to the Department when the calculation was made. The numbers provided do not represent actual loadings from the sources.

Pets

Pets (especially dogs) could be a significant source of coliform pollution through surface runoff within the Tenmile Creek WBID boundary. Studies report that up to 95 percent of the fecal coliform found in urban stormwater can have nonhuman origins (Alderiso et al., 1996; Trial et al., 1993).

The most important nonhuman fecal coliform contributors appear to be dogs and cats. In a highly urbanized Baltimore catchment, Lim and Olivieri (1982) found that dog feces were the single greatest source of fecal coliform and fecal strep bacteria. Trial et al. (1993) also reported that cats and dogs were the primary source of fecal coliform in urban subwatersheds. Using bacteria source tracking techniques, it was found in Stevenson Creek in Clearwater, Florida, that the amount of fecal coliform bacteria contributed by dogs was as important as that from septic tanks (Watson, 2002).

According to the American Pet Products Manufacturers Association (APPMA), about 4 out of 10 U.S. households include at least 1 dog. A single gram of dog feces contains about 2.2 million fecal coliform bacteria (van der Wel, 1995). Unfortunately, statistics show that about 40 percent of American dog owners do not pick up their dogs' feces. The number of dogs within the Tenmile Creek WBID boundary is unknown. Therefore, the statistics produced by APPMA were used in this analysis to estimate the possible fecal coliform loads contributed by dogs.

Using information from the Florida Department of Revenue's (DOR) 2009 Cadastral tax parcel and ownership coverage contained in the Department's geographic information system (GIS) library, residential parcels were identified using DOR's land use codes. The number of households within the Tenmile Creek WBID boundary was estimated to be approximately 1,605. Assuming that 40 percent of the households in this area have 1 dog, there are about 642 dogs within the WBID.

Assuming that 40 percent of dog owners do not pick up their dogs' feces, the total waste produced by dogs and left on the land surface in residential areas in the WBID is approximately 115 kilograms/day. The total load produced by dogs is about 2.54×10^{11} counts/day of fecal coliform.

It should be noted that this load only represents the fecal coliform load created in the WBID and is not intended to be used to represent a part of the existing load that reaches the receiving waterbody. The fecal coliform load that eventually reaches the receiving waterbody could be significantly less than this value due to attenuation in overland transport. **Table B.1** shows the waste production rate for a dog (450 grams/animal/day) and the fecal coliform counts per gram of dog waste (2,200,000 counts/gram).

Table B.1. Dog Population Density, Wasteload and Fecal Coliform Density Based on the Literature (Weiskel et al., 1996)

This is a four-column table. Column 1 lists the animal type (dog), Column 2 lists the population density, Column 3 lists the wasteload, and Column 4 lists the fecal coliform density.

- = Empty cell/no data
* Number from APPMA

Animal Type	Population Density (animals/household)	Wasteload (grams/ animal-day)	Fecal Coliform Density (counts/gram)
Dog	0.4*	450	2,200,000

The human population of 3,964 in the Tenmile Creek watershed was calculated based on the average persons per household. This value was calculated by using the average persons per household in St. Lucie County (U.S Census) of 2.47 person/household, and then multiplying by the number of occupied residential units within the WBID boundary as determined using the 2009 Cadastral information (FDEP GIS) of 1,605 households.

Septic Tanks

Septic tanks are another potentially important source of coliform pollution in urban watersheds. When properly installed, most of the coliform from septic tanks should be removed within 50 meters of the drainage field (Minnesota Pollution Control Agency, 1999). However, the physical properties of an aquifer, such as thickness, sediment type (sand, silt, and clay), and location play a large part in determining whether contaminants from the land surface will reach the groundwater (USGS, 2010). The risk of contamination is greater for unconfined (water-table) aquifers than for confined aquifers because they usually are nearer to land surface and lack an overlying confining layer to impede the movement of contaminants (USGS, 2010).

Sediment type (sand, silt, and clay) also determines the risk of contamination in a particular watershed. "Porosity, which is the proportion of a volume of rock or soil that consists of open spaces, tells us how much water rock or soil can retain. Permeability is a measure of how easily water can travel through porous soil or bedrock. Soil and loose sediments, such as sand and gravel, are porous and permeable. They can hold a lot of water, and it flows easily through them. Although clay and shale are porous and can hold a lot of water, the pores in these fine-grained materials are so small that water flows very slowly through them. Clay has a low permeability (USGS, 2010)."

Also, the risk of contamination is increased for areas with a relatively high ground water table. The drain field can be flooded during the rainy season, resulting in ponding and coliform bacteria can pollute the surface water through stormwater runoff. Additionally, in these circumstances, a high water table can result in coliform bacteria pollution reaching the receiving waters through baseflow.

In addition, watersheds located in karst regions are extremely vulnerable to contamination. Karst terrain is characterized by springs, caves, sinkholes, and a unique hydrogeology that results in aquifers that are highly productive (USGS, 2010). In comparison to non-karst areas, the springs, caves, sinkholes, etc act as direct pathways for pollutants to enter waterbodies.

Septic tanks may also cause coliform pollution when they are built too close to irrigation wells. Any well that is installed in the surficial aquifer system will cause a drawdown. If the septic tank system is built too close to the well (e.g., less than 75 feet), the septic tank discharge will be within the cone of influence of the well. As a result, septic tank effluent may enter the well, and once the polluted water is used to irrigate lawns, coliform bacteria may reach the land surface and wash into surface waters through stormwater runoff.

A rough estimate of fecal coliform loads from failed septic tanks within the Tenmile Creek WBID boundary can be made using **Equation B.1**:

$$L = 37.85 * N * Q * C * F \qquad \textbf{Equation B.1}$$

Where:

L is the fecal coliform daily load (counts/day);
N is the number of households using septic tanks in the WBID;
Q is the discharge rate for each septic tank (gallons/day);
C is the fecal coliform concentration for the septic tank discharge (counts/100mL);
F is the septic tank failure rate; and
37.85 is a conversion factor (100 mL/gallon).

Based on data obtained from FDOH, which is currently undertaking a project to inventory the use of onsite treatment and disposal systems (i.e., septic tanks) by determining the methods of wastewater disposal for developed property sites statewide, 492 housing units *(N)* within the Tenmile Creek WBID boundary are known or thought to be using septic tanks to treat their domestic wastewater (**Figure B.1**). FDOH's parcel data were obtained from the Florida Department of Revenue 2008 tax roll. FDOH's wastewater disposal data were obtained from county Environmental Health Departments, wastewater treatment facilities, Department domestic wastewater treatment permits, existing county and city inventories, and other available information. If there was not enough information to determine with certainty whether a property used a septic system, FDOH employed a probability model to analyze the characteristics of the property and estimate the probability that the property was served by a septic tank.

The discharge rate from each septic tank (*Q*) was calculated by multiplying the average household size by the per capita wastewater production rate per day. Based on the information published by the Census Bureau, the average household size for St. Lucie County is about 2.47 people/household. The same population densities were assumed within the Tenmile Creek WBID boundary. A commonly cited value for per capita wastewater production rate is 70 gallons/day/person (EPA, 2001). The commonly cited concentration (*C*) for septic tank discharge is 1×10^6 counts/100mL for fecal coliform (EPA, 2001).

No measured septic tank failure rate data were available for the WBID when this TMDL was developed. Therefore, the failure rate was derived from the number of septic tanks in St. Lucie County based on FDOH's septic tank inventory and septic tank repair permits issued in both counties as published by FDOH (available: http://www.doh.state.fl.us/environment/OSTDS/statistics/ostdsstatistics.htm).

Based on FDOH's 2008–09 inventory, the cumulative number of septic tanks in St. Lucie County on an annual basis was calculated by subtracting the number of issued septic tank installation permits for each year from the current number of septic tanks in the county, assuming that none of the installed septic tanks will be removed after being installed (**Table**

B.2). The reported number of septic tank repair permits was also obtained from the FDOH website.

Based on this information, the annual discovery rates of failed septic tanks were calculated and are presented in **Table B.2**. The average annual septic tank failure discovery rate for St. Lucie County is approximately 0.46 percent. Assuming that failed septic tanks are not discovered for about 5 years, the estimated annual septic tank failure rate is about 5 times the discovery rate, or 2.30 percent for St. Lucie County. Based on **Equation B.1**, the estimated fecal coliform loading from failed septic tanks within the Tenmile Creek WBID boundary is approximately 7.41 x 10^{10} counts/day.

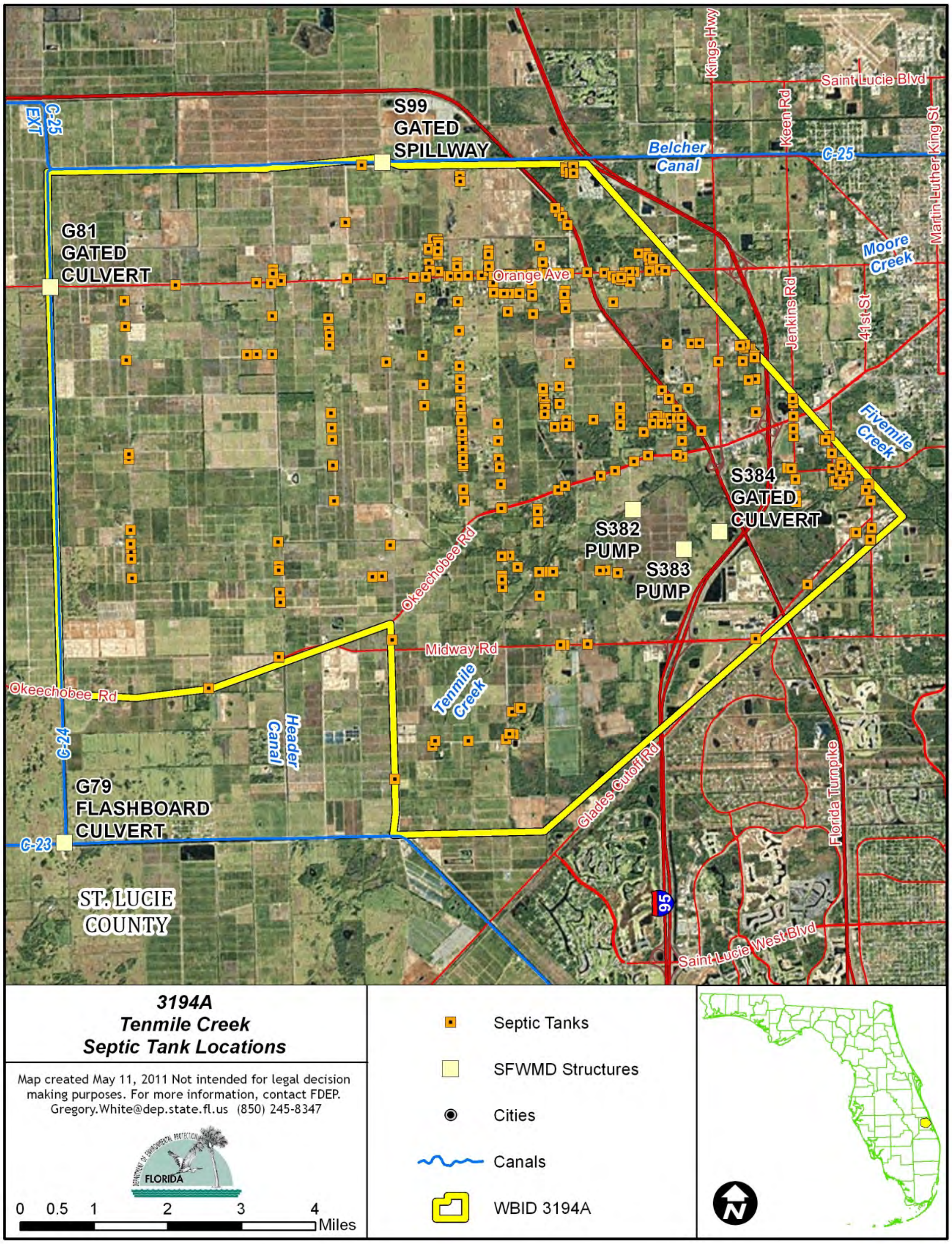

Figure B.1. Distribution of Onsite Sewage Disposal Systems (Septic Tanks) in the Residential Land Use Areas within the Tenmile Creek WBID Boundary

Table B.2. Estimated Number of Septic Tanks and Septic Tank Failure Rates for St. Lucie County (2002–08)

This is a ten-column table. Column 1 lists the type of statistic, Columns 2 through 9 lists the estimate for each year from 2001 to 2008, respectively, and Column 10 lists the average.

[1] The failure rate is 5 times the failure discovery rate.

Descriptive Statistic	2001	2002	2003	2004	2005	2006	2007	2008	Average
New installations (septic tanks)	431	544	813	679	478	297	89	47	422
Accumulated installations (septic tanks)	40,555	40,986	41,530	42,343	43,022	43,500	43,797	43,886	42,452
Repair permits (septic tanks)	302	243	231	201	207	152	116	95	193
Failure discovery rate (%)	0.74%	0.59%	0.56%	0.47%	0.48%	0.35%	0.26%	0.22%	0.46%
Failure rate (%)[1]	3.72%	2.96%	2.78%	2.37%	2.41%	1.75%	1.32%	1.08%	2.30%

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) can also be a potential source of fecal bacteria pollution. Human sewage can be introduced into surface waters even when storm and sanitary sewers are separated. Leaks and overflows are common in many older sanitary sewers where capacity is exceeded, high rates of infiltration and inflow occur (i.e., outside water gets into pipes, reducing capacity), frequent blockages occur, or sewers are simply falling apart due to poor joints or pipe materials. Power failures at pumping stations are also a common cause of SSOs. The greatest risk of an SSO occurs during storm events; however, few comprehensive data are available to quantify SSO frequency and bacteria loads in most watersheds. Therefore, in this report, the possible fecal coliform load contributed by sewer line leakage was estimated based on an empirical leakage rate of 0.5 percent of the total raw sewage (Culver et al., 2002) created within the WBID by the households connected to the sewer system.

The number of properties connected to the sewer system was based on data obtained from the Florida Department of Health's (FDOH) ongoing inventory of wastewater treatment and disposal method for developed properties. Using information from the DOR's 2009 Cadastral tax parcel and ownership coverage, residential parcels were identified using DOR's land use codes. The final number of households within the WBID boundary was calculated by adding the number residential units on the parcels for all improved residential land use codes. As a result, it was estimated that 1,113 housing units within the Tenmile Creek WBID boundary are served by sewer systems.

Fecal coliform loading from sewer line leakage can be calculated based on the number of people in the watershed, typical per household generation rates, and typical fecal coliform concentrations in domestic sewage, assuming a leakage rate of 0.5 percent (Culver et al., 2002). Based on this assumption, a rough estimate of fecal coliform loads from leaks and SSOs within the Tenmile Creek WBID boundary can be made using **Equation B.2.**

$$L = 37.85 * N * Q * C * F \qquad \textbf{Equation B.2}$$

Where:

L is the fecal coliform daily load (counts/day);
N is the number of households using sanitary sewer in the WBID;
Q is the discharge rate for each household (gallons/day);

C is the fecal coliform concentration for domestic wastewater (counts/100mL);
F is the sewer line leakage rate; and
37.85 is a conversion factor (100mL/gallon).

The number of households *(N)* within the Tenmile Creek WBID boundary served by sewer systems is estimated to be 1,113. The discharge rate through sewers from each household (*Q*) was calculated by multiplying the average household size for the St. Lucie County (2.47persons/household) (US Census Bureau, 2000) by the per capita wastewater production rate per day (70 gallons/day/person). The commonly cited concentration (*C*) for domestic wastewater is $1x10^6$ counts/100 mL for fecal coliform (EPA, 2001). The contribution of fecal coliform through sewer line leakage was assumed to be 0.5 percent of the total sewage loading created from the population not on septic tanks (Culver et al., 2002). Based on **Equation B.2**, the fecal coliform loading from sewer line leakage in the WBID is approximately 3.64×10^{10} counts/day.

Wildlife

Wildlife is another possible source of fecal coliform bacteria within the Tenmile Creek WBID boundary. As shown in **Figure 4.1**, wetland areas border the Tenmile Creek and several of its contributing branches within the WBID boundary. Additionally, rangeland (dry prairie, shrub, and brushland) and upland forested areas are close to the creek. These areas likely serve as habitat for wildlife that has the potential to contribute fecal coliform to the creek. However, as these represent natural inputs, this TMDL does not assign any reductions to these sources.

Livestock

The presence of livestock and other agricultural animals can results in high loading rates of pathogens to soils and waters. Livestock with direct access to the receiving water can contribute to exceedances during wet and dry weather conditions. Problems with grazing animals and pathogen loading rates derive primarily from animal density (Hubbard et al., 2004). At low densities, concerns relate primarily to livestock having free access to waterbodies, where they can directly deposit urine and manure (Hubbard et al., 2004). At high densities, concerns relate to the large amounts of urine and feces that are deposited in relatively small areas, increasing the probability of nutrients and pathogens being transported to surface waterbodies via surface runoff, or entering ground water (Hubbard et al., 2004).

Since agriculture is one of the primary land uses in the WBID (Agriculture and rangeland make up 75% of the waterbody), a potentially important nonpoint source of source of bacteria loading within the watershed can be grazing livestock, primarily cattle.

The estimate of fecal coliform loads from livestock for the Tenmile Creek WBID was derived from the EPA document, *Protocol for developing pathogen TMDLs: Source assessment* (2001). Data from the U.S. Department of Agriculture (USDA) (2006) were used to obtain the numbers of livestock for St. Lucie County, and data from the SFWMD's 2004-2005 land use coverage were used to obtain total pastureland areas for the county. Livestock counts and pasture areas were used to determine livestock densities (e.g., number of cows per acre of pastureland) for St. Lucie County, with the assumption that livestock are evenly distributed over pasture areas within the county.

Pasture areas of the WBID were used with the livestock density for the county to obtain livestock counts within the waterbody. **Table B.3** summarizes the pastureland acreage estimated for St. Lucie County and WBID 3194A, as well as the livestock densities per acre of pastureland estimated for the county. **Table B.4** summarizes cattle populations in St. Lucie County and provides an estimate of livestock populations for WBID 3194A in 2005.

Table B.4 also includes an estimate of fecal coliform loads produced by cattle in the waterbody. These loads were obtained based on the cattle densities estimated for the WBID and the fecal coliform counts that the American Society of Agricultural Engineers (ASAE) (1998) estimates for fecal indicator for cattle (1×10^{11} counts/day). The total fecal coliform load produced by cattle in the Tenmile Creek WBID is about 1.05×10^{14} counts/day.

Table B.3. Summary of Pastureland Acreage in St. Lucie County and WBID 3194A, and Livestock Densities per Acre of Pastureland for St. Lucie County

This is a three-column table. Column 1 lists the geographic area, Column 2 lists the acres of pastureland, and Column 3 lists the cattle per acre of pastureland.

*Assumed to be the same as that of St. Lucie County

Geographic Area	Acres of Pastureland	Livestock (Cattle) per Acre of Pastureland
St. Lucie County	26,000	1
Tenmile Creek (WBID 3194A)	1,055	1*

Table B.4. Summary of Livestock Populations in St. Lucie County and WBID 3194A, and Fecal Coliform Loads for WBID 3194A

This is a four-column table. Column 1 lists the type of livestock, Column 2 lists the livestock population in St. Lucie County in 2007, and Column 3 lists the estimated livestock population in WBID 3194A in 2005.

[1] USDA, 2007

Livestock Type	Livestock in St. Lucie County in 2007[1]	Estimated Livestock in WBID 3194A in 2005	Fecal Coliform Density (counts/day)
Cattle	26,000	1,055	1.05×10^{14}

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